AISRP 2008 PI Workshop

May 5 – 7, 2008

Adelphi, MD

Abstracts

aisrp.nasa.gov

AISR PI Meeting 2008: Draft Agenda

Monday, May 5, 2008

8:00 AM	Registration	
9:00 AM	Joe Bredekamp *NASA HQ*	Welcome and AISR Program Update
9:30 AM	Session 1.1	
	James Head *Brown University*	ADVISER: Optimizing Science Return
	Mike Turmon *JPL*	Classification of Solar Imagery and Prediction for Nonlinear Systems
	Robin Morris *USRA-RIACS*	Improving Remote Sensed Data Products Using Bayesian Methodology for the Analysis of Computer Model Output
10:30 AM	Break	
10:45 AM	Session 1.2	
	Michael Broxton CMU/*NASA ARC*	Automated DTM Generation for HiRISE and LROC
	James Tilton *NASA GSFC*	Subdue ing RHSEG...
	Lutz Hamel *University of Rhode Island*	Exploration of Novel Methods to Visualize Genome Evolution
12 Noon	Lunch	
1:00 PM	Session 1.3	
	Vinay Kashyap *SAO/CXC*	Calibration Uncertainty and Data Analysis
	Ashit Talduker *JPL*	Global cyclone detection and tracking (GLYDER)
	Kevin Knuth *SUNY Albany*	Bayesian Source Separation for Astrophysical Spectra
	Olfa Nasraoui *University of Louisville*	Mining Solar Loops to Support Studies of the Coronal Heating Problem
	David Wettergreen *Carnegie Mellon University*	Automated Orbital Mapping: Statistical Data Mining of Orbital Imagery to Analyze Terrain, Summarize its Characteristics and Draft Geologic Map

	Tomasz Stepinski *Lunar and Planetary Institute*	Automated Identification and Characterization of Landforms on Mars
3:00 PM	Break	
3:20 PM	Session 1.4	
	Ralph Lorenz *JHU APL*	Intelligent Sensor Network Study of Dust Devils
	Martin Weinberg *U MASS*	Enabling Bayesian Inference for the Astronomy Masses
	Kiri Wagstaff *JPL*	Detecting Surface Changes via Dynamic Landmarking
	Timothy Newman *Univ of Alabama Huntsville*	Auroral Phenomenon Localization, Classification, and Temporal Evolution Tracking
	Adnan Ansar *JPL*	Multi-modal Image Registration and Mapping
	Jay Johnson *PPPL*	Higher-Order Statistical Methods for Geospace Data
	Gabor Toth *University of Michigan*	Development of an Adaptive MHD Simulation Tool
	K. Palaniappan *Univ of Missouri-Columbia*	Massively Parallel Imagery Assimilation Using the 3D Multiscale Multicomponent Modeling Framework (MMMF)
6:00 PM	Adjourn	

Tuesday, May 6, 2008

8:30 AM	Session 21.	
	Kanna Rajan *Monterey Bay Aquarium Research Institute*	Adaptive Control for Underwater Vehicles
	Simon Krughoff *Univ of Washington*	Google Sky
	Bob Hanisch *STScI*	NVO Directions
	Ani Thakar *JHU*	Large Scale on Demand Cross-Matching with Open SkyQuery
	Hillol Kargupta *Univ. of Maryland, Baltimore County*	Distributed and Peer-to-Peer Data Mining for Scalable Analysis of Data from Virtual Observatories
10:10 AM	Break	
10:30 AM	Session 2.2	
	D. Aaron Roberts *NASA GSFC*	Valley of Death: Mid-Level TRLs
	Thomas McGlynn *NASA GSFC*	Presence, Personalization and Persistence: A New Model for Doing Science in a Collaborative Archive Environment
	Ed Shaya *University of Maryland*	Automated Data Analysis with Knowledge Ontologies
	Roy Williams *Caltech*	A New Network for Gamma-Ray Bursts and other Immediate Astronomical Events
	Pasquale Tricarico Planetary Science Institute	A Distributed Computing System Supporting Near Earth Asteroids Research
12:10 PM	Lunch	
1:00 PM	Session 2.3	
	Patrick Coronado *NASA GSFC*	Direct Readout: Saving the Earth in 90 Minutes
	Tamas Gombosi *University of Michigan*	Development of an Adaptive Non-Ideal MHD Simulation Tool for Multiple Space Science Applications
	Peter MacNeice *NASA GSFC*	Magnetogram Synthesis - A Vital Data Analysis Component of A Space Weather Prediction

		Infrastructure
	Kevin Olson *Drexel University*	PARAMESH: A parallel, adaptive, grid tool for the Space Sciences
	John Houck *MIT*	HYDRA: A New Paradigm for Astrophysical Modeling, Simulation, and Analysis
	Andrew Ptak *Johns Hopkins University*	On-the-fly and Grid Analysis of Astronomical Images for the Virtual Observatory
3:00PM	Break	
3:20 PM	Session 2.4	
	Kenneth Mighell *NOAO*	Parallel-Processing Astrophysical Image-Analysis Tools
	James Schombert *Univ of Oregon*	Hacking for Science
	R. Daniel Bergeron *University of New Hampshire*	Visualization of multiresolution time series data
	Jeff Scargle *NASA Ames*	Novel Methods for the Analysis of Photon-Limited Data
	Robin Morris USRA RIACS	Event Analysis for GLAST
	Michael Burl *JPL*	Directed Exploration of Complex Systems
	Simon Krughoff *University of Washington*	Next Generation Data Visualization
5:30 PM	Adjourn	
6:30 PM	Group Dinner	

Wednesday, May 7, 2008

8:30 AM	Session 3.1	
	Tsengdar Lee *NASA HQ*	Modeling Guru
	Mark Giulliano *STScI*	Multi-Objective Optimal Scheduling for Space Science Applications
	John Dolan *Carnegie Mellon University*	An Analytical Tool for Robot Mission Reliability Prediction
	Alan Sussman *Univ of Maryland*	Robust Grid Computing using Peer-to-Peer Services
	Martin Lo *JPL*	MTool Data Analysis and Visualization
10:20 AM	Break	
10:40 AM	Session 3.2	
	Edward Belbruno *Innovative Orbital Design, Inc.*	Mission Extension Using Sensitive Trajectories and Autonomous Control
	Tamal Bose *Virginia Tech*	Challenges in On-Board for Future Missions
	Aravind Dasu *Utah State Univ*	SATH: a simulated annealing to hardware compiler
	Brian Williams *MIT*	Diagnosing Complex Software and Hardware
12 Noon	Lunch	
1:00 PM	Session 3.3	
	Volodymyr Kindratenko *NCSA-UIUC*	Astrophysical Algorithms on Novel HPC Systems
	Alexander Panasyuk *SAO*	Innovative Techniques for Producing Line-of-Sight Corrected Synoptic Maps
	Rahul Ramachandran *University of AL Huntsville*	A Distributed Knowledge Extraction Framework Based on Semantic Web Services
	Mark Richardson *Caltech*	Planetary Atmospheric Data Assimilation System

	Jeff Jewell *JPL*	EPISODE - Software for Trajectory Generation and Nonlinear Continuous Control in the Presence of Uncertainty
	Kaichang Di *Ohio State University*	Integration of Orbital, Descent and Ground Imagery
	Daniel Sorin *Duke University*	Autonomic Computer Hardware for Space Missions
	Nand Lal *NASA GSFC*	AISRP Code Repository
3:30 PM	Joe Bredekamp *NASA HQ*	Closing Remarks

James W Head
james_head@brown.edu
ADVISER: Optimizing Science Return
James W Head III, Andrew Forsberg , John Huffman, Samuel Fulcomer, James Dickson
Brown University

ADVISER (Advanced Visualization in Solar System Exploration and Research) is designed to: 1) advance space science knowledge, exploration capabilities, teaching and outreach, and 2) research advanced visualization tools for space science and education through a problem solving environment (PSE). Geoscientists explore planetary surfaces with virtual, extended versions of traditional field tools to solve significant scientific problems. The ADVISER PSE has four basic parts: 1) Geoscientist on the surface, 2) Importation and visualization of integrated data sets, 3) Field kit development, and 4) Ancillary virtual field instrument development. We have: 1) Imported and visualized multiple data sets (MOLA altimetry and HRSC digital terrain models, HiRISE and CTX ultra-high resolution images, CRISM high spatial and spectral resolution imaging spectrometer data) and wind vectors and values for different seasonal atmospheric and climate conditions. 2) Placed 50 geoscientists on the surface of Mars to address scientific problems. 3) Prototyped important aspects of the field kit and ancillary field instruments (e.g., virtual photography, virtual GPS, and the PDA field notebook) and provided geoscientists with these tools in the IVR environment. 4) Continued integrating ROAM3 rendering system into the IVR environment; built toolkit on top. 5) Provided support for non-immersive desktop and immersive display environments. 6) Integrated ArcMap to formalize the initial correlation of data sets for importing to the IVR environment. 7) Developed tablet PC pen-based UI to traverse planning application of ADVISER. 8) New science results: Analysis of: a. Ancient regional glaciation on Mars, b. Tropical mountain glaciers, c. Valley networks on Mars, d. Lakes on ancient Mars, e. Recent gully formation on Mars, f. Antarctic Dry Valley gully and slope streak analogs, g. Lobate debris aprons. Antarctic Dry Valley Field planning: To prepare for deployment for the 6-week field season in the Dry Valleys, we imported digital topography and IKONOS image data to the IVR environment and planned camp locations and field traverses. Results from this season are being placed in this environment for further correlation and analysis. 80 students used the facility to plan the exploration of scientifically interesting sites on Mars.

1) These efforts fulfill the fundamental goals and objectives of the NASA AISR program, and address the major goals of NASA as an agency, including the President s Exploration Initiative.

2) Relevant technologies: Interactive 3D terrain visualization with very large data sets (high-resolution topography, image and related data) and user interface development.

3) Initiation of application to NASA Astronaut Candidate Training: Used for site selection and traverse planning for a human reference mission to Mars for broad concept certification for NASA Astronaut training.

1) Undergraduate university students filled out forms on their use and analysis of the facility and made suggestions for improvement.

2) Graduate students have discussed and described their experiences with students and faculty with all IVR facility personnel in attendance. More detailed reports are underway.

3) Interested undergraduates are doing hands-on work to help explore optimal user interface ideas (e.g., hand-held PDA device controls and applying the latest video-game-like rapid response controls).

1) Incorporation of the IVR facility for an Engineering course on mission design (continuing).

2) Integration with navigation system: how to plan for field work and establish traverse planning highlights with ArcGIS in order to optimize the planned input to the IVR facility.

3) Develop tool functionality in desktop version to: a) bring ADVISER capabilities to the Geoscience lab, b) enable comparison of ADVISER tasks done in Cave (CVV) and at conventional desktop.

4) Develop initial mechanisms for tele-robotic viewing within Brown.

5) Develop initial mechanisms for tele-robotic viewing outside of Brown at NASA and with other users.

6) Develop data management solutions for out of core data sets.

7) Develop techniques so that large data sets have low impact on interactivity (high frame rate and low latency).

8) Continue to develop advanced visualization and rendering techniques so that large geology data sets can be viewed in immersive VR (i.e., high frame rate, low latency, without inducing cybersickness).

9) Continue debriefing by user systems.

10) Extend to additional science themes and topics.

Robin D. Morris

rdm@riacs.edu

Improving Remote Sensed Data Products Using Bayesian Methodology for the Analysis of Computer Model Output

Robin D Morris *USRA-RIACS*

Athanasios Kottas *UCSC*

Roberto Furfaro, Barry Ganapol *U of Arizona*

Developed the theory and implementation for computing the main effects and sensitivity indices for the Leaf-Canopy-Model Radiative Transfer Model that predicts the radiation reflected from a forest canopy. This revealed some new effects regarding which biophysical parameters were most important to determining the reflection in certain spectral bands. A presentation was made at the AGU Fall Meeting. A paper has been accepted for publication in IEEE Transactions on Geoscience and Remote Sensing.

NASA is responsible for the operation of numerous remote sensing satellites, and for producing biophysical data products from the returned data. This project will help determine and quantify the level of uncertainty in these data products, which has important scientific and public policy implications.

We will track citations to our publications, and downloads of code once it is made publicly available.

We are extending the LCM model to predict Bi-directional reflectance, which is important for the problem of inverting the LCM model. We will address the inversion problem, and validate the model with archived satellite and field data.

Michael J. Broxton
michael.broxton@nasa.gov

Automated DTM Generation for HiRISE and LROC

http://ti.arc.nasa.gov/visionworkbench/

Michael J. Broxton *CMU/NASA Ames Research Center*
Laurence Edwards *NASA Ames Research Center*
Ross Beyer *SETI/NASA Ames Research Center*

In this, the first of three years for this proposal, we have completed the steps necessary for software compatibility between the NASA Ames Stereo Pipeline (ASP) and the USGS Integrated Software for Imagers and Spectrometers (ISIS). ISIS contains the authoritative collection of camera models for NASA imagers on interplanetary spacecraft, and the ASP can now use any pair of ISIS camera models to build digital terrain models (DTMs). Significant scalability improvements have also been made in order to support extremely large imagery for the HiRISE and LROC imagers. Finally, in preparation for extremely large data processing jobs, new enhancements enable distributed operation of the Stereo Pipeline on NASA s Columbia supercomputer.

Digital Terrain Models (DTMs) at the meter-scale derived from HiRISE and other high resolution imagers enable a variety of scientific investigations that will lead to new discoveries about Mars and the Moon. Depositional histories, crater morphology, erosion processes, and other studies of planet morphology rely on 3D data, however the availability of high resolution DTMs has historically been limited due the expense and manpower needed to produce them. The ASP is now poised to provide scientists with DTM generation software that can be run on their own workstations. The new, tighter integration with ISIS will ease adoption of the software, since ISIS is a image processing toolchain to which many scientists are accustomed.

The ASP is built on the NASA Vision Workbench, our open source image processing toolkit. The core components of the stereo image processing algorithms were released in December of 2007 as part of the Vision Workbench. We track membership on the Vision Workbench project mailing list, which now includes over 40 individuals at institutions including NASA Goddard, NASA JPL, Google, and MIT/Woods Hole.

The first objective of this project in 2009 is to validate the work done in 2008 via a comparison of HiRISE DTMs of the Candor Chasma region of Mars. This study will be carried out in cooperation with the USGS. Once the software has been validated, an open source release of the stereo pipeline will be prepared for distribution to scientists at Arizona State University, U. of Arizona, the USGS, and other institutions. Additional improvements and refinements to the software will be ongoing.

James C Tilton
James.C.Tilton@nasa.gov

Subdue ing RHSEG...

James C. Tilton *NASA GSFC*
Diane J. Cook, Nikhil Ketkar *Washington State University*

Our project seeks to integrate a graph based knowledge discovery system called Subdue with image segmentation hierarchies produced by a hierarchical image segmentation approach called RHSEG. It is expected that RHSEG segmentations will abstract the image pixel data into region objects from which Subdue will be able to discover or identify meaningful patterns and relationships.

A successful combination of RHSEG and Subdue will lead to more effective data analysis, data mining and knowledge discovery for NASA data. The product is not yet ready to be used by others.

We will continue to experiment with interfaces between the hierarchical segmentations produced by RHSEG and the Subdue system. Once this interface is made workable, we will experiment with characterizing various patterns in several types of remotely sensed image data.

Lutz Hamel
hamel@cs.uri.edu

Exploration of Novel Methods to Visualize Genome Evolution

http://bioinformatics.cs.uri.edu/gpx/

Lutz Hamel *University of Rhode Island*
J. Peter Gogarten *University of Connecticut*

We have adapted the use of bipartition spectra for comparative genome analyses. We have applied self-organizing maps, an artificial neural network approach to unsupervised learning, to genomic quintet and bipartition data. We have constructed an online analysis tool that automates some of the analysis steps.

Early life on Earth has left a variety of traces that can be utilized to reconstruct the history of life, e.g., the fossil and geological records, and information retained in living organisms. Our research focuses on how information can be gained from the molecular record, i.e. information about the history of life that is retained in structure and sequence of macromolecules found in extant organisms. The interpretation of the molecular record necessitates its calibration with respect to the geochemical and fossil records, and needs to consider and incorporate information about biochemical pathways and evolutionary theory. The analyses of the mosaic nature of genomes using phylogenetics will be a key ingredient to unravel the life s early history. Anonymous tracking of the number of times our online tool is accessed.

Applying self-organizing maps (SOM) and locally linear embedding (LLE) to larger groups of genomes. This will necessitate to reformulate the way we represent the genome relationships, we need a more robust format, in this case quartets rather than bipartition data.

Vinay Kashyap

vkashyap@cfa.harvard.edu

Calibration Uncertainty and Data Analysis

http://hea-www.harvard.edu/AstroStat/calerr/

Vinay Kashyap, Hyunsook Lee *SAO/CXC*

David van Dyk *UC Irvine*

Rima Izem *Harvard*

CHASC, et al. *CXC/Eureka/Harvard*

We have demonstrated that our scheme to incorporate calibration uncertainties into data analysis via modification of MCMC in the context of Chandra/ACIS-S effective area uncertainties. We have shown that it does work and gives results consistent with brute force calculations at a fraction of the computational cost. We are developing a robust standard that can be used with any mission, for any instrument, and one that can be generalized to different schemes of encoding of the uncertainties.

We deal directly with a major source of analysis error, viz., the uncertainty in instrument calibration and how it affects inference. This is therefore relevant to all NASA missions.

The code is not public yet, but we intend to make it public in a year or so, and will make it available via the CHASC web site. We plan to further generalize our method to account for uncertainties in spectral response and telescope point spread functions. We also intend to publicise these results amongst astronomers so that calibration scientists will create the relevant files and other astronomers will use these products in their analyses. The eventual goal is to have these methods be available generally in popular analysis software such as Sherpa and XSPEC.

Ashit Talukder
Ashit.Talukder@jpl.nasa.gov

Global cyclone detection and tracking (GLYDER)

Data Analysis and Visualization

http://eis.jpl.nasa.gov/~atalukde/

Ashit Talukder, Shen-Shyang Ho, Timothy Liu, Bingham *Jet Propulsion Laboratory*

Novel technology development and Capabilities:

1. New transfer learning mechanism to transfer information between multiple satellite data for remote global cyclone detection and tracking

2. Ensemble classifiers designed for robust classification of cyclones from remote QuikSCAT data

3. Improved segmentation and feature extraction techniques for cyclone region segmentation with minimal false alarms

4. Automated the procedure to pull QuikSCAT datasets for specified date/time/swath on demand from remote databases (earlier approach involved manual extraction that was tedious and time-consuming)

5. Prediction of cyclone evolution for constrained, faster and more efficient cyclone tracking from noisy remote satellite data 6. Integrated code for cyclone detection and false alarm rejection from QuikSCAT single sensor data

Significant Science Results

1. Developed and demonstrated capability (offline) to track hurricanes with a 3-hour temporal resolution by combining multiple satellite measurements - this is unprecedented

2. Demonstrated GLYDER remote cyclone detection system on entire 2005 calendar year

   a) Demonstrated capability to successfully detect all 25 documented tropical cyclones for Year 2005

   b) Demonstrated detection of four cyclones 72 hours before National Hurricane Center

   c) One cyclone started as extra-tropical cyclone and evolved later to tropical cyclone (detected first by GLYDER, reported later by NHC)

   d) Detected one unknown tropical event not reported National Hurricane Center - under science evaluation

   e) Numerous undocumented extra-tropical cyclones in 2005 detected with GLYDER - demo of truly GLOBAL cyclone detection

• Software IT Products to characterize global cyclone variability

• Tools that empower climate scientists to study, quantify spatiotemporal variability of cyclones on a truly global basis

• Tools for Data providers to tag cyclone metadata and enable content-based searching • Evaluating direct use of GLYDER in cyclogenesis, to better study the evolution of events before they become cyclones

• Potential use of GLYDER in mission operational environment for detecting and tracking global tropical and extra-tropical cyclones in near-real time (using NRT QuikSCAT and NRT TRMM)

• Working closely with hurricane researchers at JPL/NASA to evaluate science use of GLYDER in cyclogenesis

• Exploring the possibility of putting the GLYDER software toolkit on the web (such as the JPL Hurricane Portal)

•Test our implementation over longer time scale in a region that have multiple cyclone occurrences

•Include TRMM 2B25 swath data to construct a vertical profile of reflectivity for cyclone detection

•Explore transfer learning for cyclone detection

• Explore Active learning strategies for improved classifier design

•Explore potential of integration with near real-time data streams

• Disseminate GLYDER to scientists working with the GLYDER team

• Test toolkit for cyclogenesis and early evolution of cyclones

• Integrate GLYDER software technology components to build a single usable toolkit

• More comprehensively pursue science use of GLYDER by climatologists and hurricane researchers.

Kevin H Knuth

kknuth@albany.edu

Bayesian Source Separation for Astrophysical Spectra

http://knuthlab.rit.albany.edu/2 3

Kevin H. Knuth, Deniz Gencaga *University at Albany*

Duane F. Carbon *NASA Ames Research Center*

We have developed the ON/OFF constituent model for Bayesian source separation and applied it to the problem of detecting polycyclic aromatic hydrocarbons (PAHs) in infrared emissions from star-forming regions. This technology enables researchers to estimate the quantity of a substance independent of an estimate of its presence. We have also developed models for Planck blackbody spectra and implemented them within the nested sampling framework, so that we can estimate the parameters for multiple simultaneous blackbodies along the line-of-sight.

We are applying these source separation techniques to the problem of characterizing polycyclic aromatic hydrocarbons (PAHs) in infrared emissions from star-forming regions. The ON/OFF methodology enables us to differentiate between the case where a substance is present, but in small quantities, from the case where the substance is absent. This methodology will find use in any source separation application where presence and quantity are both to be estimated for data. We expect that this computational technology will be of great use to Raman spectroscopy in Planetary missions.

At this stage, the product is not available for use by others. In the future, the code will be made available on our website and the AISRP Code Repository. We will log downloads from our website and ask for users to volunteer data regarding the usage.

We have applied these techniques to synthetic spectra. We plan to further refine the algorithm, and to begin testing on real datasets from the Infrared Space Observatory and the Spitzer Space Telescope. We will also be porting these algorithms to our Beowulf cluster to improve data analysis speeds.

Olfa Nasroui

Mining Solar Loops to Support Studies of the Coronal Heating Problem

Olfa Nasraoui *University of Louisville*

Joan Schmelz *University of Memphis*

Background: The search for interesting images (with coronal loops) is by far the most time consuming aspect of coronal heating studies. Prior to this project, this process was performed manually, and was therefore extremely tedious, and hinders the progress of science in this field. Our project aims to develop an approach based on data mining to quickly sift through massive data sets downloaded from the online NASA and ESA solar image databases and automatically discover the rare but interesting images with solar loops, which are essential in studies of the Coronal Heating Problem. The solar loop mining scheme will rely on the following components: (i) Collection and labeling of a sample data set of images coming from both categories (with and without solar loops), (ii) An optimal feature selection strategy that will facilitate the retrieval task, (iii) A classification strategy to classify the transformed image into the correct class, and (iv) Appropriate measures to validate the effectiveness of the loop mining process. This project is divided in several phases that target the image databases collected by two different instruments, EIT aboard the NASA/European Space Agency spacecraft, SOHO, and NASA s TRACE data sets.

Highlights: The latest activities involved working on improving the detection rate for the out-of-disk loops in EIT solar images as well developing good detectors for the in-disk loops. Our greatest effort has been in addressing three difficult and continuing challenges: (i) labeling, (ii) better feature construction, (iii) handling imbalanced data sets. In (i) *labeling*, we had to develop an interactive tool for label correction at the level of individual blocks. This was necessary to correct some of the inconsistencies in labeling by the experts, and to correct errors when the labels are propagated to the blocks after automated block extraction. In (ii) *better feature construction*, we investigated more complex feature construction techniques, mostly based on: developing curvature features for imperfect and noisy edges, including spatial information, edge cleaning techniques to apply before curvature construction, and using a newly developed stream clustering algorithm to mine the optimal peak locations from huge and noisy Hough accumulator arrays. Our clustering algorithm is successful, however the biggest challenge has been in devising the most appropriate features for loop detection, based on its outputs. In (iii) *handling imbalanced data sets*, we investigated over-sampling and under-sampling techniques, compared to adaptive sampling machine learning techniques such as boosting. In particular, we applied SMOTE-based oversampling, but concluded that it only helped raise the recall metric slightly, but at an unacceptable decrease in precision. Boosting on the other hand, yielded the best results. In addition to the above, we have continued collecting more labeled examples to improve our classification models, and ran extensive cross-validation experiments to compare different feature constructions and different classifiers, and to study the effect of solar cycle information on the results.

Significance to NASA Missions: The search for interesting images for coronal temperature analysis (with coronal loops) amounts to searching for a needle in a haystack, and therefore hinders the fast progress of science in this field. The next generation EIT called MAGRITE, on NASA s Solar Dynamics Observatory, will require state of the art techniques to sift through the massive wealth of data to support scientific discoveries. Our work supports the goals of the Applied Information Systems Research (AISR) program, since it develops novel information technology and computational methods that promise to increase productivity of the OSS research and public outreach endeavors, and would benefit the state-of-practice in space science. Our work helps to increase science and educational return from the data through advanced knowledge discovery methodologies. Automatic detection of coronal loops can help in understanding and predicting solar weather which has a significant impact on space missions, satellites, and the Earth.

Software and Publications: Our software is currently on the internal project collaboration platform website: ``http://webmining.spd.louisville.edu/twiki/bin/view/SOLARLoops/ . This includes not only the full-fledged solar loop mining system with all the expert labeling, training and validation models, but also the tools for final testing of complete images (for both out of disk and in-disk EIT data). We have several conference and journal publications, including some that have been submitted, and still under review. We also have a completed thesis (by Heba Elgazzar) that describes the methods details and results from the early phases of the project.

Upcoming Plans: We plan to continue work on improving our feature construction and classification techniques, working on improving both accuracy of the results and scalability to massive data sets. We also plan to incorporate online learning that will fold new labeled examples into older models instead of re-training our models from scratch. Our final phase that targets TRACE data sets, has also just began, and will require not only borrowing from some of the lessons learned and techniques developed for EIT data, but also new methods that are specialized for this data set, due to its distinguishing characteristics. As our cross-validation results reach a more stable state, we will be more active in submitting publications.

Tomasz F. Stepinski
tom@lpi.usra.edu

Automated Identification and Characterization of Landforms on Mars

Tomasz Stepinski *Lunar and Planetary Institute*

The project has resulted in a software for an automatic survay of impact craters on Mars and an automatic survay of valley networks on Mars. A new catalog of Martian craters was constructed using the software. Using the new catalog a global maps of craters depth/diameter ratio are produced. These maps show a striking pattern that can be interpreted by an existance of subsurface ice at high latidudes. NASA is focused on studying Mars surface and subsurface. Craters are one of the most important landform features on Mars and other planets. Cataloging them yields wealth of geologic information. Developed software can be applied to the Moon and Mercury once elevation data for these planets become available. The valley networks survey software has been given to two other scientist who has asked for it. It has also been ported as the Web service. The crater identification software is available at cratermatic.sourceforge.net/ where it downloads can be tracked directly. In the last year we are planning to finish the global catalog of craters and submit it to the Planetary GIS Webservice. We also planning on finishing a global database of valley networks and also submit it to the Planetary GIS Webservice.

Ralph D. Lorenz
ralph.lorenz@jhuapl.edu

Intelligent Sensor Network Study of Dust Devils

Data Management

http://www.lpl.arizona.edu/~rlorenz

Ralph Lorenz JHU Applied Physics Laboratory

So far (yr 1), demonstrated potential for inexpensive data acquisition platforms to acquire spatially-resolved data.

Dust devils are an aviation hazard on Earth, and a factor in rover operations at Mars. They are an important dust-raising mechanism on both planets, with implications for climate and air quality.

Will refine approaches tested last year, and explore potential of new technologies (specifically an array of wireless sensor motes for real-time data acquisition and monitoring)

Martin D. Weinberg
weinberg@comcast.net

Enabling Bayesian inference for the astronomy masses

http://www.astro.umass.edu/~weinberg/bie

Martin D. Weinberg, Neal Katz, Houjun Mo, Elilot Moss *University of Massachusetts*

1) Bayesian tool for inferring galaxy properties from images shown to be robust even in low S/N regimes, low bias compared to currently used approaches (e.g. GALFIT). Full posterior simulation allows hypothesis testing for an ensemble of images.

2) Bayesian semi-analytic modeling tool has revealed multiple modalities for fit to luminosity function. Current SAM incorporates physics of many research groups, and will allow hypothesis testing.

3) Alpha-testing persistence subsystem allowing all states of a Bayesian analysis (e.g. MCMC posterior, data, etc.) to be stored, commented and reused for future investigations.

1) General efficient parallel platform for Bayesian computation of astronomical data (any data really . . .).

2) Platform for multiple discipline investigator collaborations to share infrastructure (e.g. astronomers and statisticians, extragalactic and planetary research).

3) System allows script-based prototyping and a C++ library for production suitable for mission data pipelines.

Currently by download recording. When the standalone packages become available next year, we plan to have follow-up questionnaires and a wiki in addition to registration and download recording. Core science applications underway in three areas:

1) bulge to disk correlations with luminosity and environment for 2MASS/SDSS selected input image catalog.

2) SAM modal analysis and inter-research-group hypothesis testing underway.

3) LMC metallicity/population/structure star-count analyses underway.

Papers planned for the upcoming year.

Kiri L. Wagstaff
kiri.wagstaff@jpl.nasa.gov

Detecting Surface Changes via Dynamic Landmarking

Kiri L. Wagstaff, Adnan Ansar *Jet Propulsion Laboratory*
Melissa Bunte, Ron Greeley *Arizona State University*
Norbert Schorghofer *University of Hawaii*

This project began in November, 2007. We have developed new methods for automated landmark selection and for surface change detection. The landmark selection methods are based on statistical measures of local terrain salience and entropy. We have applied these methods to several Mars surface images collected from orbit. Using annotations provided by our science collaborators (dark slope streaks and dust devil tracks), we are able to quantify the salience of different types of surface features when used as landmarks. In parallel, we have developed advances in conventional change detection methods based on pixel registration. Ultimately, we plan to combine these techniques together to yield highly efficient ways to identify, and classify, surface changes.

Our landmark selection and change detection methods provide techniques that can be useful both onboard a remote spacecraft and in ground processing on the Earth. In an onboard setting, salient landmarks can be detected and catalogued as they are observed, providing a highly compressed summary of the region under study. On the ground, more intensive processing can be used to register images collected at different times and then identify changes. Further, we plan to apply additional processing to detected landmarks to classify them into known categories (e.g., crater, ridge, gully, dune, dust devil track, dark slope streak) as well as to flag any unusual landmark types that may not previously have been identified. This capability will permit us to automatically generate semantic annotations for the large body of archived images, ultimately supporting a content-based search facility that can permit scientists as well as the general public to quickly find images that contain a specific feature of interest.

We do not yet have a product that is available for use by others, but this will change in the coming years of this project.

First, we will conduct a more extensive evaluation of our landmark selection and change detection methods on a large body of MOC and THEMIS images. We will develop hybrid methods that leverage the strengths of landmark-based change detection (obtaining salient regions instead of individual pixels) and pixel-based change detection (very high detection rates even for areas that may not be salient). Next, we will train a landmark classifier to label each selected landmark with its general type. We will also develop a representation for Regional Landmark Graphs (RLGs) to characterize the landmarks structure of a given region, and to enable recognition of the same region when it is observed in subsequent images.

Timothy Newman

tnewman@cs.uah.edu

Auroral Phenomenon Localization, Classification, and Temporal Evolution Tracking Methods

T. Newman *UAHuntsville Computer Science*

G. Germany *UAHuntsville CSPAR*

J. Spann *NASA MSFC / NSSTC*

C. C. Hung *Southern Polytechnic St. Univ.*

New methodologies for localizing aurorae and auroral phenomena in NASA Polar UVI and IMAGE FUV imagery are described. The methods are largely driven by exploitation of known auroral shape constraints. The methods are primarily aimed at enabling web-based retrieval of images of interest from two large image archives. Preliminary benchmarkings of the methods effectiveness are also reported.

Our work enables increased exploitation of NASA mission data. The work is aimed at directly aiding space science, particularly the study of Sun-Earth systems.

Site hits (counts and region-of-origins) on the legacy web tool are monitored. When the new tool is activated, we plan to use the same scheme. The methods developed for UVI are currently being employed in the upgrade of the capabilities of an existing web-based search interface. The methods developed for FUV will be used to build a new web-based tool for retrieval of FUV imagery.

Adnan Ansar

ansar@jpl.nasa.gov

Multi-modal image registration and mapping

Adnan Ansar, Larry Matthies *JPL*

We have developed a prototype multi-modal image matcher capable of automatically matching images across such sensor modalities as visible, thermal and radar. In this context, imagery refers to the data product of any sensor capable of generating a 2d pixel representation. Preliminary tests on Cassini, Mars and terrestrial datasets are very promising

The primary driver for this work is to enable localization of a Titan aerial vehicle by matching mosaicked aerial data to orbital sensor data. This enables a critically needed high-precision localization capability that is unlikely to be achieved in any other way. Our work applies equally well to any mission, such as small body proximity operations, requiring spacecraft localization from low orbit using high orbital reference imagery. In addition to the implications for navigation, the matching result itself is relevant for landing site selection for future Mars and other lander missions, where image overlays from multiple sensors are currently generated by hand. Similarly, there is a potential for automatic matching of ground-based mosaics to orbital imagery for use in rover localization. Finally, a pixel level automatic registration of data across sensor modalities will be of considerable benefit in both space and terrestrial science applications.

Our product is in the early development stage. However, we have made contacts with and obtained data from Cassini mission scientists, the Phoenix landing team and terrestrial / atmospheric scientists. We have also discussed our work with and received guidance from the Titan outer planets mission study team. We will feed results back to these groups as we proceed and take guidance from them in developing our tools.

Having demonstrated proof of concept, we are now working on optimization and improving robustness. Among the areas under development for this year are incorporation of scale / orientation invariance and image warping to accommodate inconsistent ortho-rectification of data products. We will also be studying in detail the feasibility of transitioning this work to an FPGA implementation for use in flight. Future efforts will include work on structure from motion to enable ortho-rectification and mosaicking in the presence of 3D relief, map building, and integration of our methods into a full estimation framework.

Jay R. Johnson
jrj@pppl.gov

Higher-Order Statistical Method for Geospace Data

Jay Johnson *Princeton University*
Simon Wing *The Johns Hopkins University*

Development of method for extracting nonlinear dependencies in geospace data sets using mutual information, cumulants and transfer entropy. Have identified solar cycle nonlinearity in space data associated with high speed solar wind streams. Examined issues of causality and information flow in space systems. Methods may be used to identify nonlinearity in geospace data sets and access an information horizon for data flow. Identification of nonlinearity is useful for modeling efforts. Determination of causality and information flow is important to build predictive models (for example of hazardous space weather conditions) and to determine the extent to which predictive models can be improved. Contacts and citations. Plan to upload product and monitor access of webpage. Investigate coupling function for solar wind-magnetosphere interactions. Examine dimensionality of space data and compression of data stream through dimensional. Investigate causality using entropy based measures with applications to magnetospheric processes for which the cause and effect remain unclear.

Gabor Toth
gtoth@umich.edu

Development of an Adaptive MHD Simulation Tool

http://csem.engin.umich.edu

Gabor Toth, Tamas Gombosi, Darren De Zeeuw, Kenneth Powell
CSEM, University of Michigan

Over the last 15 years our group at the University of Michigan has been developing a general use global MHD code, BATS-R-US, and the Space Weather Modeling Framework (SWMF) that couples domain models extending from the Sun to planetary upper atmospheres and ionospheres. BATS-R-US and SWMF have been extensively used to simulate a broad range of space science phenomena. Still there are many unmet challenges. There is a need to go beyond ideal MHD. In the previous AISRP we have developed a new parallel implicit Hall MHD solver for the 3D block-adaptive grid used in BATS-R-US. In the current AISR project we went further and developed a two-fluid MHD model with a separate electron pressure equation and we have developed a general multi-ion MHD model. These models are fully implemented into BATS-R-US, but they still require improvements. We have already used the new multi-ion solver to simulate the magnetosphere of Earth with ion sources coming from the polar wind. The polar wind code PWOM is coupled to BATS-R-US through the SWMF framework. We are going to develop an MHD model with a non-isotropic pressure. We will also implement a new time stepping scheme into BATS-R-US that allows the various subdomains to evolve at the rate allowed by the local stability conditions.

Having a more accurate physics model and a more efficient solver allows us to do a better job in modeling the solar corona, the magnetosphere and the space environment in general. These technologies are relevant to the following NASA goals: Understand the Sun and its effects on Earth and the solar system. Advance scientific knowledge of the origin and history of the solar system, the potential for life elsewhere, and the hazards and resources present as humans explore space. The SWMF and BATS-R-US are freely available via registration at the CSEM web site. The codes are available for runs on request at the Community Coordinated Modeling Center (CCMC). CCMC maintains a database of all runs and also requires notification about publications using CCMC runs. Our codes are also used extensively by the researchers and students at CSEM. Further improve the multi-ion MHD model. Further develop and apply the two-fluid MHD model. Develop and implement the non-isotropic pressure model. Designing the algorithm for the local time stepping.

Kanna Rajan

Kanna.Rajan@mbari.org

Adaptive Control for Underwater Vehicles

http://www.mbari.org/autonomy/TREX/index.htm

Kanna Rajan MBARI

We have developed and deployed an onboard Adaptive Control System that integrates Planning and Probabilistic State Estimation in a hybrid Executive. The resulting system is a unified representational and computational framework based on declarative models and constraint-based temporal plans. The work is motivated by the need to explore the oceans more cost-effectively through the use of Autonomous Underwater Vehicles (AUV), requiring them to be goal-directed, perceptive, adaptive and robust in the context of dynamic and uncertain conditions. The novelty of our approach is in integrating deliberation and reaction over different temporal and functional scopes within a single model, and in breaking new ground in oceanography by allowing for precise sampling within a feature of interest using an autonomous robot. The system is general-purpose and adaptable to other ocean going and terrestrial platforms.

Onboard autonomy is critical to NASA s needs for unmanned deep space exploration. As light time travel increases, spacecraft cannot be joy-sticked from Earth and will require onboard autonomy to ensure their health and safety as well as critical mission needs are satisfied. The tools and techniques we have developed are based on a decades worth of experience at NASA Ames and flown on NASA s DS1 spacecraft and used on the ground for command and control of the two MER rovers at JPL. We expect further use of such techniques as the agency moves towards Lunar and Martian exploration.

Informal collaborations and working within a privately funded non-profit organization like MBARI, allows us to give away our code. To date the extensive code-base is being used by LAAS, Toulouse France (in collaboration with IFREMER, the French national Oceanographic agency), National Institute of Oceanography, Goa, India and Willow Garage a not-for-profit Silicon Valley startup in Robotics.

We work closely with MBARI scientists in Microbiology, Biological and Chemical Oceanography in an inter-disciplinary environment which is science driven. Our near term commitments are the following:

1. to characterize blooms and ocean Fronts in 4D (space and time) by sampling and observation using Autonomous Underwater Vehicles (AUVs).

2. to enable mixed-initiative control of AUVs using shore to vehicle communication and robust onboard commanding to ensure the platforms meet evolving needs.

3. enable persistent long-duration mission operations of AUVs by encapsulating fault conditions leading to replan scenarios automatically and onboard.

Hillol Kargupta

hillol@cs.umbc.edu

Distributed and Peer-to-Peer Data Mining for Scalable Analysis of Data from Virtual Observatories

www.cs.umbc.edu/~hillol/Kargupta/ddmVO/

Hillol Kargupta, Agnik Kamalika Das, Kanishka Bhaduri, Wesley Griffin *UMBC*

Kirk Brone *George Mason University*

Chris Giannella *Loyola College*

1. Explored the problem of fundamental plane analysis from distributed astronomy data available from different virtual observatories. Performed a series scientific data analysis tasks in order to better understand the problem.

2. Developed communication efficient distributed and peer-to-peer data mining algorithms for large distributed environments. This project will develop technology for mining high-througput distributed data Astronomy data sources. The goal is to develop a collection of scalable local algorithms that will be able to quickly analyze distributed data repositories and streams in communication efficient manner. We are currently exploring fundamental plane computation and outlier detection techniques for distributed data mining. These techniques should allow Astronomy researchers to identify unusual phenomena and objects of interest quickly from large volume of distributed data.

Research publications are the current products of this research. The impact of these papers can be tracked using citation indices. We plan to explore several distributed data mining algorithms. We are also collaborating with Astronomers regarding practical deployment of these algorithms for solving several science problems. This involves exploring detailed scientific explorations of the virtual observatory data.

The immediate plan is to identify a collection of scientific tasks that are likely to be used by Astronomers and develop efficient techniques for performing those using distributed data mining techniques.

Pasquale Tricarico
tricaric@psi.edu

Orbit@Home

Computational Methods

http://orbit.psi.edu/

P. Tricarico *Planetary Science Institute*

During the first two months of this project, we have reached the point where a our first application is available for all major platforms, and is being debugged with the help of thousands of volunteers from around the world. Its purpose is to realistically simulate the performance of Near Earth Asteroids (NEAs) surveys. Once into production, this is expected to help enhance NEAs discovery rate.

Distributed computing (DC) provides a virtually unlimited amount of computational power. With orbit@home we try to demonstrate that moving toward DC is both easy and necessary in order to enable qualitatively new science, in the form of very large scale numerical simulations or data analysis. All volunteers are automatically tracked using a client/server mechanism. We plan to keep all our products freely accessible. Feedback and network statistics can provide an estimate of the users base.

We will produce extensive simulations of NEAs surveys, and then apply the same approach to the real NEAs population to try to improve the discovery rate.

Tamas I. Gombosi
tamas@umich.edu

Multifluid MHD Simulations of the Magnetosphere

Tamas Gombos, Gabor Toth University of Michigan, Alex Glocer
University of Michigan

There are several critical research areas where single-fluid treatment is not an adequate representation of the basic physics. These areas include space weather, where the ionosphere is a major source of heavy ions that contribute to the formation of the ring current and thus to magnetospheric dynamics. Single-fluid description is clearly inadequate to describe many space weather phenomena. We developed and implement a multifluid MHD model that is part of a flexible, high-performance, robust, accurate and widely available simulation tool.

The proposed research is relevant for the following NASA strategic goals and outcomes:

 Strategic Goal 3.2: Understand the Sun and its effects on Earth and the solar system.
NASA Science Outcomes:

 Progress in understanding the fundamental physical processes of the space environment from the Sun to Earth, to other planets, and beyond to the interstellar medium.

 Progress in understanding how human society, technological systems, and the habitability of planets are affected by solar variability and planetary magnetic fields.

 Progress in developing the capability to predict the extreme and dynamic conditions in space in order to maximize the safety and productivity of human and robotic explorers.

 Strategic Goal 3.3: Advance scientific knowledge of the origin and history of the solar system, the potential for life elsewhere, and the hazards and resources present as humans explore space.

At this stage the new features are tested and they are not used by others. However, our Space Weather Modeling Framework is widely used by the space physics community and it is available at the CCMC. We will develop a two-fluid (electron-ion) Hall MHD capability to simulate CMEs and planetary magnetospheres.

Peter J. MacNeice

Peter.J.MacNeice@nasa.gov

Magnetogram Synthesis

Peter MacNeice *NASA/GSFC*

Joel Allred, Kevin Olson *Drexel University*

We have only begun and the first funding increment has not yet arrived at the time of this submission. We have developed reading and reformating routines for almost all of the primary magnetogram sources and have implemented the first simple processing widgets for our initial GUI design.

This work is highly relevant to NASA s Space Weather monitoring and prediction capabilities, and to its solar and heliospheric research activities. Not yet required.

We will extend our development of the lightweight processing layer and begin studying the most useful algorithms for minimizing spurious current densities in magnetograms synthesized from multiple sources.

Kevin Olson
Kevin.M.Olson@drexel.edu

PARAMESH: A parallel, adaptive, grid tool for the Space Sciences

http://www.physics.drexel.edu/~olson/paramesh-doc/

Kevin Olson *Drexel University*

C interface Parallel IO Divergence of B control Improved performance PARAMESH has been integrated into major scientific codes: FLASH astrophysics code at the University of Chicago and HAHNDOL general relativity code at NASA/GSFC. Science Projects: 1) Large Scale general relativity simulations of colliding black holes performed at NASA/AMES under the direction of Joan Centrella. 2) Large scale simulations of Type Ia supernovae (University of Chicago FLASH code). Black hole simulations are directly relevant to the LISA project. Informally via e-mail. Future plans for PARAMESH are tentative. Currently funding is being sought for further development and support of PARAMESH.

John C. Houck
houck@space.mit.edu

HYDRA: A New Paradigm for Astrophysical Modeling, Simulation, and Analysis

http://space.mit.edu/hydra/

John C. Houck, Dan Dewey, Michael S. Noble, Michael A. Nowak, John E. Davis
MIT

During the past year we have developed software to do forward folding and comparison of 3D source models with 2D event-based data sets. These routines build on the volumetric 3D routines developed during our first year of funding. We have continued working to define a software interface that can be used to handle more general optimization problems. We have also continued to explore ways to use parallel computation to speed up various data analysis tasks. These technologies support more thorough science analysis of observational data obtained by NASA spacecraft such as the Chandra X-ray Observatory and also from ground-based instrumentation. - In adding new capabilities we plan to focus on ways to make better use of parallel processing.

Andrew Ptak

ptak@pha.jhu.edu

On-the-fly and Grid Analysis of Astronomical Images for the Virtual Observatory

http://www.xassist.org

Andrew Ptak *Johns Hopkins University*

Andrew Connolly, Simon Krughoff *University of Washington*

Web services for requesting the processing of X-ray data, retrieving X-ray analysis results, and analyzing more than one optical image simultaneously (i.e., with one for source detection and another for photometry). Optical source detection includes automatic correlation with request astronomical tables. The joint X-ray/optical system has not been made public yet but will be shortly.

These technologies will lead to better usage of NASA archival astronomical data, most notably from HST and X-ray missions. Once the services become public and registered we will track their usage from the access logs.

Publishing the web services, more advanced web services for X-ray analysis (most notably computing upper limits, which can be critical for including X-ray data in virtual observatory queries), and formalizing our approach for combining similar web services for different data (optical and X-ray) that include wavelength-specific features (e.g., X-ray data include spectral information rather than just images).

Kenneth J. Mighell

mighell@noao.edu

Parallel-Processing Astrophysical Image-Analysis Tools

http://www.noao.edu/staff/mighell/aisr

Kenneth J. Mighell National Optical Astronomy Observatory

During the past year, the PI has worked closely with Bill Hoffmann and Bill Glaccum, both members of the Spitzer Space Telescope s Infrared Array Camera (IRAC) Instrument Team, to demonstrate that his AISR-funded MATPHOT algorithm for precision stellar photometry and astrometry yields a significant improvement in photometric precision of IRAC Ch1 stellar observations over the best results obtained with aperture photometry using the recommended calibration procedures in the IRAC Data Handbook: the relative peak-to-peak spread was reduced by a factor of 1.9 from 3.3% to 1.7% and the relative robust standard deviation decreased by a factor of 1.7 from 0.92% to 0.54%. The PI has developed a new fast parallel-processing image analysis program called CRBLASTER which does cosmic ray rejection in space-based astrophysical observations using van Dokkum s L.A.Cosmic algorithm. Processing a single 800x800 Hubble Space Telescope Wide-Field Planetary Camera 2 (WFPC2) image takes 1.87 seconds using 4 processors on a 3.0 GHz Apple Xserve; the efficiency of the program running with the 4 cores is 82%. The code has been designed to be used as a software framework for the easy development of parallel-processing image-anlaysis programs using embarrassing parallel algorithms. The goal of NASA s New Millennium Program Space Technology 8 Dependable Multiprocessor (DM) project is to conduct a comprehensive research project to investigate and develop for NASA the first supercomputer in space. The PI, working with the DM Project Team, has recently ported two AISR-funded parallel-processing applications, QLWFPC2 and CRBLASTER, to the DM-sigma software-testbed cluster and is now adding fault tolerant features to these applications so that they should be able to pass fault-injection/radiation tests which are part of the DM project s Technology Readiness Level 6 Validation effort which should start in June 2008. These technologies will enhance the science return not only of existing Spitzer Space Telescope IRAC Ch1 and Ch2 observations in the Spitzer data archive but also those that will be made during during the possible Spitzer Warm Mission which would start around April 2009 after all of the cryogen is depleted. Helping the NMP ST-8 Dependable Multiprocessor team validate NASA s first space-based supercomputer in a prototype demonstration in a relevant environment demonstrate to NASA s Technology Review Board that the fault-tolerant middleware techniques used in the DM project are useable by researchers with parallel-processing scientific analysis applications which might be suitable for use on future NASA astrophysical missions to be launched in the next decade.

While this project has no formal tracking mechanism, the PI is working closely with NASA s Spitzer Space Telescope s Infrared Array Camera (IRAC) Instrument Team and NASA s New Millenium Program (NMP) Space Technology 8 (ST-8) Dependable Multiprocessor (DM) Project Team.

The PI will continue working with the IRAC Instrument Team with the goal of developing new calibration and analysis procedures that have the potential of significantly improving the precision of point-source photometry. As part of this effort, the PI will customize the MATPHOT code to do crowded-field photometry in IRAC Ch1 images. The PI will help the DM Project Team in their TRL-6 Validation efforts. The PI will further develop the CRBLASTER code and write a paper describing it for submission to the journal Publications of the Astronomical Society of the Pacific. On June 28, 2008, the PI will give the oral presentation CRBLASTER: A Fast Parallel-Processing Program for Cosmic Ray Rejection at the SPIE-Marseille conference on Advanced Software and Control for Astronomy. On June 23, 2008, the PI, Glaccum, and Hoffmann will present the poster Improving the Photometric Precision of IRAC Channel 1 at the SPIE-Marseille conference on Space Telescopes and Instrumentation I: Optical, Infrared, and Millimeter.

James Schombert *University of Oregon*
jschombe@uoregon.edu

Hacking for Science

This project is to develop automatic scripts to monitor/retrieve data from Data Center websites. The resulting tools have an impact across a variety of science fields as the use of websites to disseminate data is prevalent. These tools will allow the general user access to new levels of data analysis.

R. Daniel Bergeron
rdb@cs.unh.edu

Visualization of multiresolution time series data

http://www.cs.unh.edu/star/

R. Daniel Bergeron, Andrew Foulks *University of New Hampshire*

The principal goal for the previous year was to integrate a basic multiresolution data support framework into the Visit environment from the Lawrence Livermore National Laboratory. Visit provides a convenient interactive environment and a wide range of existing visualization tools. By integrating our multiresolution data management into Visit, users immediately gain access to a large existing visualization code base. The software includes 3 components: STARgen, STARgui, and STARvisit plugins. STARgen is a tool for generating multiresolution data hierarchies of time series data in which each node in the hierarchy can represent reduction in either spatial resolution or temporal resolution. STARgui is a friendly interactive program that guides a user through the process of defining the desired multiresolution hierarchy. The STARvisit data plugin provides the interface between the multiresolution data hierarchy and the VisIt system. A user can change data resolutions via a simple interactive dialog which triggers VisIt to reload data from the appropriate resolution level. This tool allows a scientist to utilize Visit functionality for rendering and interactive browsing of data in concert with data resolution changes. All three components are available for download from the project web site.

One of the major challenges facing NASA scientists is effective analysis of the explosion of data that is being generated by current science technology. This is particularly a problem in the simulation of time-dependent magnetohydrodynamics (mhd) phenomena that produces enormous data sets of many hundreds of gigabytes. It is also the case that interactive visualization of the data is still one of the most effective techniques for gaining insight into the physical phenomenon. The huge size of the data, however, severely limits the ability to visualize the data in an effective interactive environment. Our multiresolution data management framework makes it easy to develop interactive environments for browsing such data. We have just made a version of the software available through web download. We do not currently require a registration in order to download.

The principal goals for the coming year include software support for adaptive resolution data and better error data generation and utilization. Our current tools allow a user to create and access data at different resolutions, but each resolution level uses the same resolution throughout the spatial and temporal domains. A more flexible data representation scheme allows a user to define a single data set in such a way that it is represented by data at different resolutions in different regions -- regions where the data values are not changing very rapidly can be represented at a lower resolution than regions in which the data is changing dramatically. Effective decisions about the resolution level require an effective model for representing the error that is introduced by using the lower resolution data. We have completed a basic utility for representing such error, but that tool has to be integrated into the data generation tool. We have also refined our vision about the kinds of error that should be available to a scientist as part of the interactive visualization environment. We will incorporate this new vision of error into future releases of our software.

Jeffrey Scargle *NASA Ames Research Center*

Jeffrey.D.Scargle@nasa.gov

Novel Methods for Analysis of Photon-Limited Data

I have outlined the plan and scope for a Handbook of Statistics for Event Data, meant to be a useful for scientists analyzing event or point data. Details will be given for two case studies, one in gamma-ray astronomy (and targeted at the Gamma Ray Large Area Space Telescope) and the other in x-ray astronomy:

(a) detection of dispersion (energy dependent lags) in time- and energy-tagged gamma-ray burst data;

(b) characterization of the variability of active galactic nuclei from time-tagged x-ray data: the shortest detectable variability scale for Mkn 421 and NGC 4151.

These studies are meant to exemplify both the general approach and specific algorithms which will be part of the Handbook.

The Handbook will be of practical use for analysis of a large fraction of all of the data obtained by NASA space or earth science missions. (GLAST, Swift, Compton GRO, RXTE and Chandra are specific cases targeted.)

The Handbook has not been released, even in draft form. For similar projects in the past, I have tracked the usage in the relatively small high-energy astrophysics community by personal communication and literature survey, and in the broader community by web-based searches of the relevant institutions and archives.

A draft of the complete Handbook will be prepared (with algorithms presented in MatLab, a high-level data language) and sent to a number of colleagues for comments and suggestions. Applications to gamma-ray and x-ray observations will be published in method papers that detail the numerical methods along side the scientific results (see #1 above).

Robin D. Morris
rdm@riacs.edu

Event Analysis for GLAST

Robin D Morris *USRA-RIACS*
Johann Cohen-Tanugi *SLAC*

Extended the methodology previously developed to analyse charged particles incident on the LAT instrument to also analyse incident gamma-ray photons. Demonstrated a statistical methodology in particle physics data analysis problems that may help resolve a controversy in the literature regarding the application of Bayesian statistical methods. An EPO video for broadcast on PBS in the San Francisco Bay Area (and potentially nationwide) is in an advanced state.

GLAST is a major NASA mission, with launch expected later this year. The methodology developed is under consideration by two potential SMEX missions.

The code is publicly available on the SLAC CVS server, but we are currently unable to track the downloads by others.

Completion of the gamma-ray analysis code, including development of the theory and code for model selection to determine the relative probabilities of the different ways of interpreting the pattern of the detector response in terms of the physical processes that occured during the event. Submission of papers describing the methodology and results.

Michael C. Burl
Michael.C.Burl@jpl.nasa.gov

Directed Exploration of Complex Systems

Michael C. Burl *JPL*
Brian Enke, William J. Merline *Southwest Research Institute*

Numerical simulations provide scientists with a valuable tool for examining massivley complex systems. However, in many simulations long run-times make a detailed, exhaustive study of the input parameter landscape infeasible. The key idea we have developed uses support vector machine (SVM) classification techniques and active learning to cleverly explore the input parameter space of a simulation. We have successfully applied this approach to a complex smooth particle hydrodynamic (SPH)/N-body simulation of asteroid collisions to narrow down plausible initial conditions (impactor size, velocity, etc.) for generation of an Emma-like asteroid family. The technique provides a significant reduction (2-fold to 10-fold or more in some cases) in the time required to explore a simulation; this savings can be parlayed in different ways depending upon the specific goals of the scientific investigation: (i) the same final result can be obtained with fewer simulation trials, (ii) more simulation trials can be conducted in a given amount of time, (iii) higher-fidelity (e.g., finer spatio-temporal resolution) simulation trials can be used, or (iv) more trials can be concentrated at the boundary between interesting and not-interesting regions of input space. In addition to publication in the scientific literature (e.g. Icarus), this work has been described in a leading computer science conference (SIAM Data Mining Conference), NASA Tech Briefs, and a JPL New Technology Report.

Simulations are widely used at NASA and other government agencies for modeling and examining processes that could not be studied otherwise. The techniques we are developing are broadly applicable to a variety of physical systems; however, our current focus has been on the asteroid collision application which specifically aids in the understanding of how the Sun s family of planets and minor bodies originated and evolved. There are also strong connections with ground observations and NASA spacecraft missions. Co-I Merline is one of the leaders in finding binary asteroid pairs using adaptive optics. He is also part of a search for small bodies near Mercury in the currently-flying MESSENGER mission. In a previous seed investigation, significant speedup in magnetospheric modeling based on data from NASA s IMAGE spacecraft was obtained.

The algorithms are still in development mode, so currently the product is only used internally.

The key goal for this year is to mature the software so that it can easily be used with a variety of simulations. A prototype Bayesian procedure for using an ensemble of multiple SVMs with different hyperparameters to model the current state of knowledge will be incorporated. In addition, we are evaluating new techniques, e.g., based on Gaussian processes, Markov Chain Monte Carlo (MCMC) sampling, and an information gain criteria, to determine the strengths and weaknesses of these approaches for different problems.

Alan Sussman

als@cs.umd.edu

Robust Grid Computing using Peer-to-Peer Services

http://www.cs.umd.edu/projects/hpsl/chaos/Research

Alan Sussman, Pete Keleher, Bobby Bhattacharjee, Derek Richardson, Dennis Wellnitz

University of Maryland

Work in the second year of the project has concentrated on algorithms and simulations to create a fully functional peer that both performs matchmaking well, and scales to large numbers of machines with no serious load imbalances. Such load imbalances can arise from both problems in the initial matchmaking process that assigns jobs to machines, and from maintaining the structured peer-to-peer (P2P) network. Much effort this year has also gone into the implementation of a usable software system. Based on the results of simulations of our initial algorithms from year 1, and the new ones from this year, we have built our first peer implementation. Initial versions of the peer software have been thoroughly tested, and a large scale evaluation with the astronomy collaborators on the project is under way. The evaluation involves running the peer software on multiple clusters and desktop machines in both the Computer Science and Astronomy departments at Maryland, on a total of well over 100 machines, and running thousands of astronomy simulations (still being determined by the astronomers) through the complete system. We intend to analyze many aspects of the system behavior through extensive logging of the peer behavior during the experiment, including overall scalability and how well our system simulations match the behavior of the real system.

The system will be used to easily share computational resources among colleagues at multiple sites, typically within a scientific discipline. Those resources can be used for large numbers of simulations, as the astronomy co-Is are doing, for data analysis, or for any other purpose requiring large numbers of independent computational jobs.

Once the software has been thoroughly tested by the astronomy co-Is, we will make the software available on the project web site for others to use. We will log downloads, and keep track of bug fix requests from users for furthre support of the software.

We are continuing to develop the algorithms for matching resource requests to available resources, in particular concentrating on multi-core and multi-processor grid nodes. Effectively utilizing such resources, which are becoming more widespread and important, is an open question that has not been addressed at all in the desktop grid community to date. Another area of ongoing research is in techniques for dynamic load balancing. Our current algorithms and implementation perform matchmaking once, when a job is submitted into a grid. That matchmaking is done using the current (approximate) state of the overall set of peers that exists at that time. We will investigate methods for determining when to initiate dynamic load balancing algorithms, to adapt to the ever changing grid environment. The algorithms for dealing with categorical resource types are being implemented in the peer software, and will be thoroughly tested and evaluated in the upcoming year. We are in the process of fully testing and deploying the software within the project, both in computer science and to the astronomy collaborators. Large scale testing of the peer in a distributed grid system is under way, and will consume the majority of the project resources in the coming, final year of the project. We will evaluate the reliability and scalability of the algorithms and implementation under real workloads, first from within the project with astronomy applications run by the astronomy co-Is on the project, and then in a wider deployment within the wider computational science community at Maryland (through the Institute for Advanced Computer Studies - UMIACS), and then to collaborators outside Maryland (especially PI Sussman s space science collaborators from the space weather modeling community).

Martin W. Lo JPL
Martin.Lo@jpl.nasa.gov

MTool Data Analysis and Visualization

1. Application of dynamical systems theory to atmospheric and ocean data.

2. Application of new 3D reconstruction techniques to visualize complex data. Using computational differential geometric methods to work with time varying 3D data.

3. These methods allow the detection and extraction of spatial temporal coherent structures from the data. Eventually, it will allow for the computation of flux and diffusion rates to characterize transport in the atmosphere and ocean from satellite and in situ observations.

1. These techniques will help NASA scientists and engineers analyze climate data and planetary science data.

2. The same techniques are applicable to the data analysis of other SMD missions such as those studying solar physics, interstellar media, wherever there are fluid problems.

3. These techniques are also useful for visualization and for 3D reconstruction from images and point cloud data.

I plan to deliver MTool 1.0 at the end of FY08. It will be delivered to several JPL users: the AIRS Instrument Project (data processing), Titan GCM Project (visualization). I plan to continue working with these users and to meet with them periodically to track the usage of MTool 1.0. This is a 1-year project. I intend to submit a new proposal to AISR and other funding opportunities based on the work accomplished this year.

Edward A. Belbruno Innovative Orbital Design & Princeton University
belbruno@princeton.edu

Mission Extension Using Sensitive Trajectories and Autonomous Control

Substantial progress has been obtained on precise visualization and computation of the weak stability region. This has enabled an understanding of new types of motions and a step towards understanding how autonomous use of this region could someday be achieved.

Understanding the WSB region gives a way to understand new types of low energy transfers and ways to stay in orbit about planets for much longer periods of time than is traditional. This would extend time for data mining. Also, fuel saving capability can allow more science to be taken on by the spacecraft due to utilization of the fuel s mass. This would enhance the science return.

This is tracked, in part, by new missions NASA is planning that make direct use of the WSB region and low energy transfers. Currently, three NASA missions are being planned to use this technology: GRAIL, LADEE, THEMIS. Science is being enhanced and enabled in all of them by the use of the WSB region. This is a substantial development. Also, publications and lectures on this topic by other people is another measure. Use of this region by foreign space programs, eg ESA is planning to use this methodology in the BepiColombo mission.

1. Hopefully, a nearly complete understanding of the WSB region in a key situation.

2. New Applications and ways to use low energy transfers resulting from the theory behind this technology.

3. Trying to give a realistic way to achieve autonomous control of a spacecraft by making use of the low energy properties of motion in the WSB.

Tamal Bose

tbose@vt.edu

Adaptive Algorithms for Optimal Classification

Tamal Bose *Virginia Tech*

Erzsebet Merenyi *Rice University*

1. Unsupervised clustering: We did benchmark clustering on our uncompressed hyperspectral test images, and are performing the same on compressed-decompressed images.

2. We developed the mathematical algorithms for optimizing the compression algorithms: (a) adaptive filters, (b) predictor models, (c) adaptive quantizers, and (d) transform coders.

3. We implemented an Adaptive Differential Pulse Code Modulation (ADPCM) based hyperspectral image coder. The coefficients of the predictor filter are adapted based on classification metrics.

4. Supervised classification of compressed and decompressed images yielded excellent results: Classification accuracy of these images remains within 2% of the classification accuracy on original uncompressed data.

Space science missions that carry spectral imagers can significantly benefit from the results of this project in scenarios where lossy data compression is needed at compression ratios as high as can be achieved without loss of relevant spectral information. Because of our approach to compression, we will be able to determine the optimal compression ratio in an adaptive manner. The fast parallel implementation of the compression and classification algorithms makes the combined system an intelligent, real-time on-board data understanding, compression and classification machine that learns on chip and adapts continuously to new circumstances as desired, modifying the compression scheme to best suit a given environment.

We will create a demo of all our algorithms and post them on the project web site. All of our compression algorithms, codes, data analysis, and images will be available on our project web site for interested users. The number of downloads and hits will be tracked.

1) We will perform classification of hyperspectral images in the transform and quantized domain. This will include experiments with a variety of transforms, compression ratios and quantizers.

2) There are two extreme cases of the availability of training data for classification. One, where there is sufficient data is available, and the other when we have no labeled training data. There are many scenarios in between where some knowledge is available on classification. We will implement and evaluate our algorithms for a representative number of these cases and accordingly modify our algorithms.

Aravind R. Dasu
dasu@engineering.usu.edu

SATH: a simulated annealing to hardware compiler

http://www.usu.edu/rcg/index.php
Dr. Aravind Dasu, Jonathan Phillips *Utah State University*

We have designed and developed an electronic system level design automation tool/compiler called SATH. This is a C to FPGA compiler specifically customized to auto-design hardware accelerator circuits for simulated annealing based algorithms.

On-board autonomy requires processing complex event scheduling tasks among others. These algorithhms are complex and highly parallelizable. Therefore to take advantage of accelerating these applications on an on-board FPGA based computer, it is necessary to design complex VLSI architectures that take several months of engineering. Through our tool (SATH), scientists and software developers who have no knowledge of hardware circuit design can feed in ANSI C code for the application and get a circuit automatically designed and ported onto an FPGA, saving months of design time and errors. -

We have started working on customized fault mitigation and tolerance circuit designs to protect the auto-generated FPGA circuit from single and multiple soft errors. Refining this methodology and optimizing the tool flow for fault protection will be the focus of our effort for the upcoming year.

Brian C. Williams
williams@mit.edu

Diagnosing Complex Software and Hardware

Brian Williams, Paul Elliott *MIT MERS*

This year has been marked by continued progress on the maturation of the mixed software and hardware monitoring capability in the context of the EO-1 mission. This capability is built upon the use of Probabilistic Hierarchical Constraint Automata (PHCA), which describe the behavior of the mixed software and hardware system to the monitoring capability. Maturation has focused on improving the expressivity of the models supported by the capability as well as improving the capacity of the algorithm to support larger models efficiently through algorithmic improvements. This year has also shown substantial progress in improving the modeling language, Reactive Model-Based

Programming Language (RMPL), used to model the PHCA. We have also improved upon the language s compiler to support generating more complex models. We have been working in collaboration with JPL on development scenarios relevant to the EO-1, both to focus the EO-1 modeling effort and to help specify correct software behavior. Using the language improvements, along with the direction of the scenarios, we ve been able to continue the evaluation of and improve upon the modeling of the EO-1 mission.

This project directly responds to the Applied Information Systems Research (AISR) program objectives of NASA s Research Opportunities in Space and Earth Sciences (ROSES). In particular, our technology is expected to enhance the science productivity of NASA s space flight missions that are sponsored by the Science Mission Directorate (SMD). This technology builds upon the success of the Autonomous Science Experiment (ASE) onboard the Earth Observing One (EO-1) mission, by providing an onboard capability for monitoring and diagnosing software and hardware systems, as well as mission goals. Enhancing the ASE software through the proposed fault management capability enables extremely high reliability operations, resulting in an increased return of scientific data. This work also directly responds to NASA s Strategic National Objective to Study the Earth system from space and develop new space-based and related capabilities for this purpose. The maturation and validation of our proposed technology in the context of EO-1 demonstrates its potential for long term impact on many future NASA missions that are increasingly relying on complex software and hardware systems.

We are still in the development phase, so most usage is in-house. We normally remain in detailed email contact with external users, both to work through issues and to see examples of the models developed for our tool. We intend to continue to mature this capability in conjunction with JPL to match the requirements of the EO1 mission.

Volodymyr Kindratenko

kindr@ncsa.uiuc.edu

Astrophysical Algorithms on Novel HPC Systems

Robert Brunner *UIUC Astronomy Department*

Volodymyr Kindratenko *UIUC NCSA*

The objective of our research is to demonstrate the practical use of alternative computing technologies, such as those based on FPGAs and GPUs, for advanced astrophysical algorithms and applications, particularly those involving very large data sets. In the past year we explored the use of multi-core CPUs, Field-Programmable Gate Array (FPGA) based co-processors, and NVIDIA Graphics Processing Units (GPUs) for accelerating two-point correlation functions which find an extensive use in cosmology applications. More specifically, i) we extended the two-point angular correlation function brute force implementation from the previous year to work on a cluster consisting of multi-core SMP nodes using Message Passing Interface (MPI), ii) implemented the compute kernel of this cluster application on a Nallatech H101 FPGA application accelerator board using DIME-C language and DIMEtalk API and expanding the application to utilize FPGA accelerators available in the cluster nodes (16 in total), and iii) experimented with the same compute kernel on the NVIDIA GPU G80 platform using CUDA development environment. On the Nallatech H101 platform we achieved a 4x-8x per FPGA kernel speedup as compared to a modern processor core while maintaining 100% accurate results and running the computations only at fraction of the power budget of the conventional system. The kernel speedup obtained on the GPU platform was more substantial: 60x. However, current generation of GPUs only supports 32 bit arithmetic, thus reducing the useful range of calculations to angular separations above 1 arcminute. We expect that we will be running full double-precision calculations on the next generation GPUs to be introduced later this year.

We achieve significant application speedup while using accelerator-based systems, which translates into the ability of NASA scientists to process much larger datasets within the same time frame as current HPC systems can process smaller datasets. This allows scientists to answer questions that otherwise can only be answered with the use of very large HPC resources, or cannot be answered at all with the current technology. Also, significant cost savings can be achieved. We are planning to release software in the upcoming year.

There are two main directions that we will continue exploring novel architectures in the upcoming year: 1) With the introduction of the double-precision floating-point GPU chips later this year, we will research and implement the two-point angular correlation kernel on this platform and will extend our existing cluster application to simultaneously take advantage of the multi-core chips as well as the Nallatech H101 FPGA accelerators and NVIDIA GPUs. We will leverage an ongoing effort in NCSA s Innovative Systems Lab on a novel run-time environment for supporting efficient use of diverse compute resources. 2) We already extended our base line k-nearest neighbor kd-tree based implementation of the instance based classification code to work on a multi-core SMP system via pthreads and tested it with multi-million point datasets. In the upcoming year we will extend this application via MPI to work on large cluster systems and will investigate the use of FPGAs and GPUs to accelerate the kd-tree based range search algorithm used in the k-nearest neighbor classifier. Our preliminary analysis shows that such an implementation could provide significant benefits in speeding up the calculations, however it is not trivial to implement a control flow dominant code on these architectures.

Alexander V. Panasyuk
apanasyuk@cfa.harvard.edu

Innovative Techniques for Producing Line-of-Sight Corrected Synoptic Maps

Alexander V. Panasyuk Harvard-Smithsonian CfA
Leonard Strachan, John L. Kohl *Harvard-Smithsonian CfA*

We present the status for a project which has as its goal to build a database of localized plasma parameters in the solar corona. The project uses more than a decade of spectroscopic data from the Ultraviolet Coronagraph Spectrometer (UVCS) on the SOHO spacecraft. UVCS measurements of line-of-sight integrated spectral profiles at three wavelengths (H I Ly-alpha, O VI 103.2 nm and 103.7 nm) are used to produce 3D maps of ion velocity distributions and bulk outflows. A previously developed algorithm for reconstructing the emissivities has been extended to include the reconstruction for the line-widths which are needed to compute accurate outflow velocities. The specifics that complicate a tomographic reconstruction of the solar corona, such as coronal dynamics, are discussed, as well as methods to estimate the uncertainties introduced in the reconstruction.

This effort uses data from the the Solar and Heliospheric Observatory (SOHO) but the algorithms developed could be used by other missions that produce imaging or spectroscopic data, even non-solar missions. We plan to set up a Web site that will allow users to download data and selected softare for visualizing the data. Usage will be tracked by logging the downloads.

For the upcoming year, we plan to

1) complete the final database of outflow velocity maps for different activity periods of solar cycle 23;

2) develop and test the data retrieval tools for selecting the data;

3) document and write a Users Manual to be supplied with the software; and

4) publish the coronal emissivity, line-width (temperature), and outflow velocity maps in an archival journal.

Sara Graves
sgraves@itsc.uah.edu

A Distributed Knowledge Extraction Framework

www.itsc.uah.edu

Sara Graves, Rahul Ramachandran, Helen Conover, Sunil Movva
University of Alabama Huntsville
Peter Fox *NCAR*
Deborah McGuiness *RPI*

Scientific data mining is a very powerful means for automated knowledge extraction from the ever-increasing volumes of science observations and model output data available. NASA s Second Data Mining Workshop found that maturing data mining techniques show potential for significantly expanding the scientific understanding of NASA s Earth science data. However, this type of tool has generally been difficult for domain scientists and students to fully exploit without extended learning curves. And even data mining specialists may not be familiar with the full range of components in a mining toolkit, so potentially useful mining strategies may be ignored. To facilitate exploitation of these promising techniques by the increasingly IT-sophisticated NASA science community, we have investigated the use of Semantic Web technologies to build a Smart Assistant for Mining via the seed funding received through the AISR program. This project has successfully designed and developed a prototype that demonstrates the value of smart assistance for mining. The prototype reuses an existing toolkit of data mining web services designed specifically for the analysis of NASA data in a web-based, service-oriented architecture. This project has also developed an initial ontology describing data mining services, with links to data ontologies. The prototype user interface tool, integrates semantic reasoning into a traditional workflow composer and allows users to discover available data and services, assist users in composing mining workflows, and invoke them to perform the desired analysis.

This prototype has successfully demonstrated that it can assist researchers in creating data analysis and mining workflows for science problems. It will also position web and grid services for integration with many other science data services in the Semantic Web Services context, pointing the way toward increased science return from NASA data.

Since this project was partially funded primarily to design, develop and test the prototype for it usefulness, no direct metrics were tracked. However, the prototype has been presented at several meetings and conferences The seed funding from AISR has been fully utilized to develop the prototype. The prototype was instrumental in successfully competing for a NASA ACCESS grant. Full scale development of the data mining and data ontologies and the tool will be completed under the NASA ACCESS program

---

Kaichang Di

di.2@osu.edu

Integration of Orbital, Descent and Ground Imagery

Ron Li, Kaichang Di, Ju Won Hwangbo, Yunhang Chen *The Ohio State University*

In FY07, we developed methods for rigorous photogrammetric processing of HiRISE (High Resolution Imaging Science Experiment) stereo images. Using the developed sensor model and bundle adjustment method, we processed HiRISE images and derived a digital terrain model and slope map of the Mars Exploration Rover (MER) Gusev Crater landing site. These mapping products helped the MER team evaluate potential routes to ¡°Von Braun¡± and find ¡°Winter Heaven¡±, enabling Spirit rover to survive the local winter. Orbital ground integration has been researched as well.

The integration of Mars orbital, descent and ground imagery has the potential to achieve the best possible accuracy for integrated Mars topographic mapping capability analysis. This research directly contributes to the AISR program high priority area ¡°to increase science return from data¡± by integrating three types of imagery and deriving topographic products and rover localization data that are far superior to those that can be derived from a single type of imagery. They are critical to MER, MSL and future landed missions. The developed method and mapping products are currently being used in MER operations by the science and engineering teams. They are using them to evaluate rover potential traverses and winter haven sites. For example, we processed a pair of HiRISE images and derived a digital terrain model and slope map of the Mars Exploration Rover (MER) Gusev Crater landing site. These mapping products helped MER operations evaluate potential routes to ¡°Von Braun¡± and find ¡°Winter Heaven¡±, enabling Spirit rover to survive the local winter. This high accuracy, integrated mapping capability will be very valuable for planetary scientists in their studies, particularly in regional geology, crater mechanics and modeling, cross-site geological processes, etc. It will greatly aid traverse planning and rover navigation strategy development for future landed missions. The developed orbital image mapping method can be directly used in future missions for landing-site selection.

We track the usage of our topographic products though daily Mars mission operation meetings, peer-reviewed publications, professional conference presentations, project reports and personal communications. We know that our products are in MER's mission briefings to NASA headquarters, team members¡¯ science papers, daily mission LTP reports and weekly mission manager's reports etc.

In FY08, we will develop techniques for extraction, modeling and matching of landmarks from orbital and ground images. We will also develop software for integrated bundle adjustment of orbital, descent and ground imagery.

Daniel Sorin

sorin@ee.duke.edu

Autonomic Computer Hardware for Space Missions

http://www.ee.duke.edu/~sorin/faultfinder/index

Daniel Sorin, Sule Ozev   Duke University

1) Provably comprehensive, low-cost, low-power detection of errors in microprocessor cores

2) An all-software technique for tolerating permanent faults in processor cores

3) An all-hardware technique for tolerating permanent faults in multicore chips

NASA s space missions depend on computer hardware, and our research enables this hardware to be reliable without user intervention and without resorting to high-cost, high-power solutions like triple modular redundancy (TMR).

We do not yet have a product, but we are building a prototype that is being partly sponsored by Toyota InfoTechnology Center. Automotive computing has many similarities to space mission computing, in terms of the need for low-cost reliability. Our work is also being used by other academic and industrial researchers.

We plan to extend error detection to other parts of the computer system, including the address translation system and I/O. We are also developing an interface between the hardware and the operating system (OS) that enables better scheduling of software threads on cores that are affected by faults and voltage/frequency scaling.

Brian Doty

doty@cola.iges.org

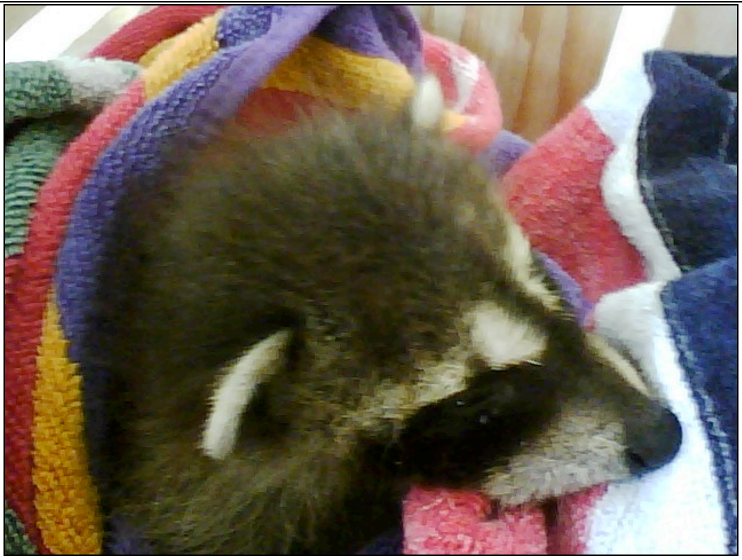
Enhancing GrADS for Earth System Science Research

Brian Doty, Jennifer Adams *IGES/COLA*

GrADS, GDS, and Greta are a suite of software packages that support the organization, access, analysis, and visualization of Earth science data. GrADS, the cornerstone of the software suite, has been in use for 20 years. Recent enhancements increase the software s capabilities to handle large, multi-member multi-ensemble data sets. The 4-dimensional gridded data model in GrADS (longitude, latitude, level, and time) has been expanded to include a 5th dimension that is generally applicable, but intended for use as an ensemble dimension. GrADS also has a new interface for handling data in the GRIB2 format, the new standard for much of the ensemble forecasts being distributed by the international forecasting centers participating in the TIGGE project.

Updates are intended to keep pace with high-end computing resources, expanding data volumes, and model output and observational data that comes in new formats and grid structures. We have metrics of usage statistics from our public GDS servers. We monitor the number of users subscribed to the GrADS users listerver. We keep track of the number of FTP downloads of the software.

We will add support for GIS-compliant output: rasterized images in the geo-TIFF format, and shapefiles that conform to the ESRI specification. We will also support the HDF5 format for gridded data. We will begin the planning and design for the support of quasi-regular swath data.



Special thanks to Rocky, who insisted he get his bottle while this booklet was being compiled. Here s hoping the little feller makes it in this world. –sh 5/3/08